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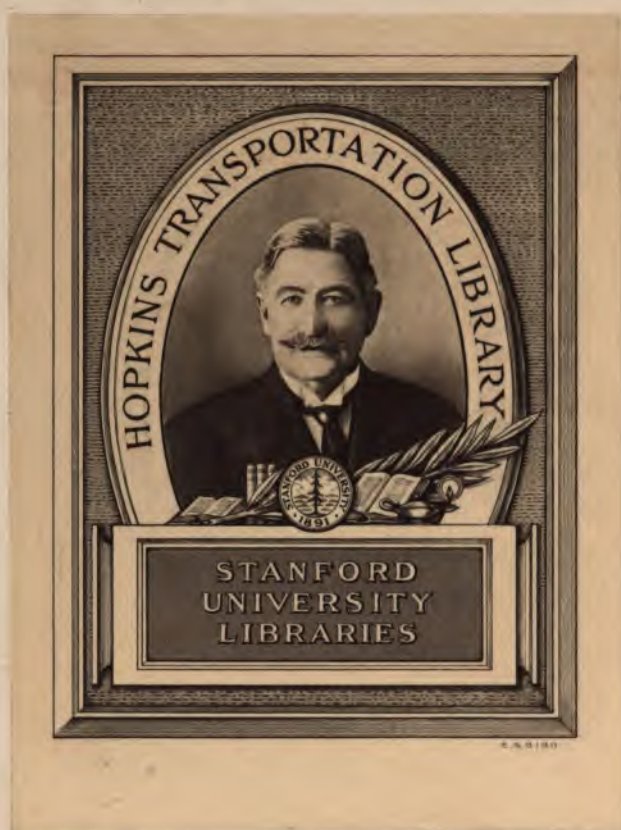
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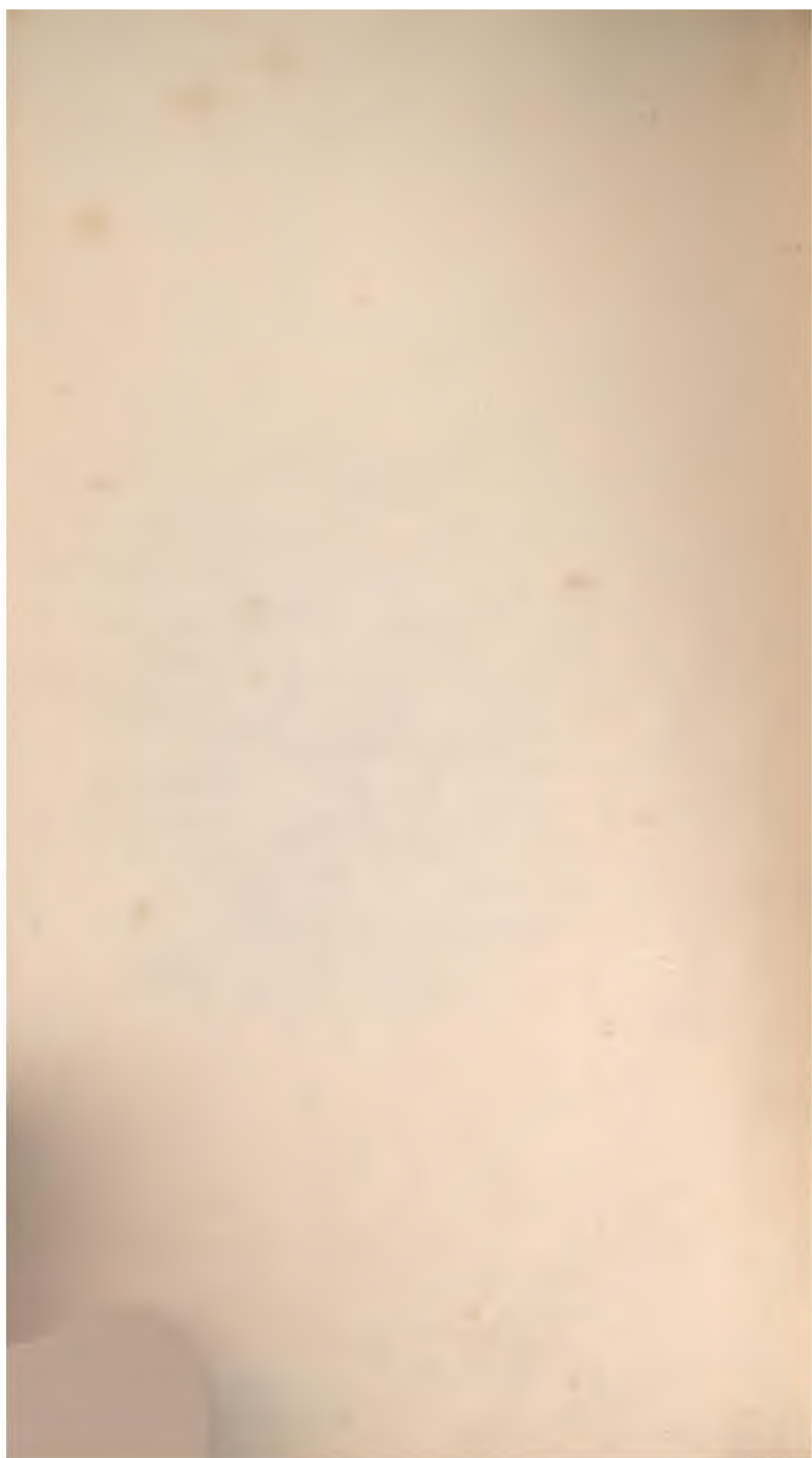
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CLEGG'S
PATENT
ATMOSPHERIC RAILWAY.

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1825.



CLEGG'S

PATENT ATMOSPHERIC RAILWAY.

RAILWAYS, notwithstanding their obvious defects, are becoming the general means of inland communication throughout Europe, and persons of all denominations are embarking capital in them. It is therefore necessary to determine the manner in which means so abundantly supplied can be laid out so as to produce the greatest possible advantage to the proprietors and the public. This object can best be attained by investigating the defects of the present system, and by showing the means of correcting them. There is scarcely in the history of this country an event more important to the interests of commerce and society in general than the introduction of railroads.

The advantages of increased speed are so highly appreciated, that a traffic has arisen by it, so extensive and productive, as to afford an adequate remuneration for the outlay of capital, however much that outlay exceeded all pre-

vious calculation. But how will that traffic be increased, and that remuneration augmented to the proprietors, if speed (the source of all their profits) can be greatly increased, the danger of accidents diminished, and the transit of goods reduced in cost to as low a rate as by canals. It is to this end that the following comparative statements are submitted to the public.

The principal defects in the present system of railroads, are the enormous expenses of constructing and working them, as well as the impossibility of obtaining a speed beyond 25 miles per hour without incurring an enormous additional expense.

These evils arise from the following causes :

1stly. From the absolute necessity of cutting down hills, raising embankments, and constructing tunnels, so as to make the road a perfect level, or nearly so.

2ndly. From the great weight of rails, chairs, and blocks required to enable the road to sustain the shocks of ponderous locomotive engines, and from the continual derangements which these shocks produce.

3rdly. From the rapid wear and tear of the locomotive engines at a mean speed of 20 miles per hour, which we will take as a high average speed on railways for passengers.

4thly. From the great consumption of fuel in proportion to the power obtained, and the costly nature of the fuel employed.

5thly. From the necessary increase of these defects when the slightest improved speed is attempted.

The first of these evils, namely, the making the road

level, is caused by the very nature of the *power* employed. The whole power of the engine is not available for the impelling of the train, because the locomotive has to drag itself and tender. Thus a great portion of its power is consumed even on a level; but that consumption is greatly augmented in contending with the slightest ascent, the power being then reduced, at the time the train is most in need of it.

The extent of this defect will be more clearly apparent by an example.

Supposing a locomotive engine to possess a gross tractive force of 1,336 lbs., and its weight, including the tender, to be seventeen tons, (this is the actual weight and tractive force of the best locomotive engines at work on the London and Birmingham and Grand Junction lines when travelling at a mean rate of twenty miles per hour,) and as 8 lbs. draws a ton on a level road, 136 lbs. will be consumed in impelling the engine and tender, leaving 1,200 lbs. available for the train. This power of 1,200 lbs. will draw a train of 150 tons weight on a level road.

We will now place the same train on an ascent of one in fifty. The power required to draw a ton is then increased from 8 lbs. to 53 lbs. or $6\frac{3}{4}$ times as much as on a level. Therefore the engine and tender, weighing seventeen tons, will consume 901 lbs. instead of 136 lbs., and will leave but 435 lbs. available for the train, instead of 1,200 lbs. But as the train now needs 7,950 lbs. to enable it to ascend, $18\frac{1}{4}$ locomotives, each possessing a tractive force of 1,336 lbs., making together a tractive force of 24,382 lbs., will be required to produce that available

force. We thus see an absolute waste of two-thirds of the power employed on an ascent of one in fifty; while, on a level, this waste is little more than one-ninth.

By the same calculation it will be seen, that, if the acclivity above named be slightly increased, the locomotive engine will not have sufficient power to draw itself and tender, even without the train.

The second evil, namely, the necessity of a great weight of rails, chairs, and blocks, and their continual derangement, is a necessary consequence of the employment of locomotive engines.

The third evil, namely, the wear and tear of the locomotive engines, is perhaps the heaviest expense in the working of a railroad; and that item is rendered still more onerous, by the necessity of having in store a large extra number to keep up an adequate supply in working order. In the year 1831, the annual expense of each locomotive, exclusive of its first cost, on the Manchester and Liverpool Railway, was found to be £2,107.* At this period, the velocity attained was from ten to fifteen miles per hour; the velocity on the same line now is increased to an average of twenty miles per hour, which has added considerably to the cost of working it.

The fourth evil, namely, the large consumption of fuel in proportion to the power obtained, arises, in part, from the great velocity in the movement of the pistons, which prevents the steam from acting on them with full effect; but principally from the necessity of contracting the waste

* *Vide* a Treatise on Roads, by the Right Honourable Sir Henry Parnell, Bart.

steam pipe, so as to obtain sufficient draft for the fire; a back pressure being thereby produced on the pistons, their force is reduced. To so great an extent is the combined action of these defects felt, that when travelling at twenty miles per hour, the effective power of the engine is reduced to half that which would be obtained from the same quantity of steam generated, and fuel consumed with a stationary engine. When travelling at thirty miles per hour it is reduced to less than one fourth; and at a speed but little exceeding forty miles, the power is so far destroyed, that the engine will draw scarcely more than itself and tender. An additional waste of fuel, to an immense extent, is also occasioned by the loss of power already shown on inclined planes.

The effect above described has been attributed by some to atmospheric resistance; but as this resistance may be ascertained by calculations formed on undisputed data, it is easily investigated. We know that air rushes into a vacuum at a velocity of 1,300 feet per second. This is produced by a pressure of 15 lb. per square inch, and therefore a body passing through the air at this velocity is met by a pressure, or resistance of 15 lb. per square inch on its front surface, or 2,160 lb. per square foot. It is also well known that this pressure varies in proportion to the square of the velocity of the body, and not in direct proportion to its velocity. Thus, by following out the calculation, it will appear that the resistance due to twenty-seven feet per second, or about twenty miles per hour, is nine-tenths of a pound per square foot; and that due to thirty miles per hour $2\frac{9}{100}$ lb. per square foot.

The front of the first carriage of the train contains about thirty square feet, and if the carriages are judiciously constructed, this will be nearly the whole surface exposed to resistance. Therefore the resistance at thirty miles per hour will be 62.27 lb., about $\frac{1}{21}$, or 5 per cent. of the tractive force cited in the first example; and at twenty miles per hour 27 lb., about $\frac{1}{49}$, or 2 per cent. of the tractive force.

From the foregoing remarks, it will appear that the evils of the present system are entirely attributable to the use of locomotive power; and the remedy must be sought for in the employment of stationary power in its stead. The means by which this can be effected, without diminishing the accommodation and advantages at present given to the public, is next to be considered; and it is confidently expected that, in the following description, will be found not only remedies for all existing evils, but also many important advantages, both in speed and safety, which cannot possibly be obtained at present.

The power employed on the system about to be described, is that of the atmospheric pressure brought into action by exhaustion. The advantages derivable from the application of this power have been long since apparent; and numerous attempts have been made to render it available, hitherto without success.

In 1824, a patent was obtained by Mr. Vallance for a mode of employing atmospheric pressure for locomotion. He proposed to form an air-tight tunnel the whole length of the railway, and large enough for the train of carriages to travel inside it. The tunnel being provided with a pis-

ton, and exhausted on one side, the pressure of the atmosphere on the other would propel the piston forward, and with it the train which was attached to it. The impracticability of this plan must be apparent to all, as, independently of the immense expense in forming *an air-tight* tunnel for the whole length of the line, the inconvenience of travelling in it for any long distance would altogether preclude its use. In 1834, Mr. Pinkus attempted to obviate these defects by using a smaller tunnel. He proposed to employ pipes, like common gutter-pipes, forty inches diameter ; and he obtained a patent for covering the lateral opening in these pipes with a rope. The covering of rope he expected would make the pipes air-tight enough to allow a sufficient vacuum being obtained in the tunnel to draw a train of carriages on the outside. A second patent was taken out by Mr. Pinkus in 1836, altering his system to a vacuum locomotive engine, and varying the cover of the lateral openings ; but neither of these plans have been carried into execution, as it was found impossible to cover the lateral opening sufficiently air-tight. These difficulties have been at length surmounted by Mr. Clegg, who has succeeded in rendering the power of the atmosphere available for locomotion with a degree of economy and perfection even beyond his most sanguine expectations.

CLEGG'S PATENT ATMOSPHERIC RAILROAD.

CLEGG'S atmospheric railroad is worked by stationary steam-engines, apart from each other two to five miles, according to the nature of the country. Two engines are fixed at each station, one for the up and the other for the down wain, excepting on long inclined planes, where one engine only is required at the same points.

The power of these engines varies according to the gradients and traffic. Supposing the traffic to be 2,500 tons per day, say 1,250 tons each way, and the velocity required to be thirty-five miles per hour, the average power employed on the line would be equal to 6-horse per mile. The size of the engines will vary from 6 to 25-horse power, according to the gradients. The power is communicated to the train by means of a main or pipe laid between the rails, which is exhausted by air-pumps worked by the engines. This pipe is divided into lengths or sections (varying according to the respective distance of the engines) by valves, which are opened by the train as it goes along; and a space is left between each section, with proper sidings for stopping the trains when necessary. The pipe suited to the above-mentioned traffic would be ten inches in diameter. A piston is fitted to the pipe in such a manner that it will slide air-tightly therein. The

pressure on the back of this piston (when the pipe is exhausted to the degree required for the steepest ascents) ~~will produce a vacuum~~ equal to a column of mercury twenty inches high.

An available tractive force is thus obtained of 714 lbs., which will draw a train weighing thirteen tons up an ascent of one in fifty. With engines of the before-named power, the train can be impelled at the rate of thirty-five miles per hour, and the sections of the pipe exhausted with sufficient rapidity to admit of a train being despatched each way every ten minutes; or, if we make allowance for all possible delay, four trains each way may be transmitted per hour, making a total of 2,496 tons per day.

To the first or driving carriage of the train an arm from the piston is attached. This arm passes through an opening about an inch and a half wide, extending the whole length of the pipe on its upper surface; and this opening is covered by a valve, the nature of which constitutes the peculiarity of Mr. Clegg's system; and is, by a simple and efficacious contrivance, rendered absolutely air-tight. The construction and action of this valve cannot be clearly explained without reference to diagrams or models; but the following account of experiments made by Messrs. Samuda, at Southwark Iron Works, will be sufficient to prove its efficacy:—

The first of these experiments was made with a pipe $3\frac{1}{8}$ inches diameter, and 30 feet in length, which was laid level, and was exhausted by an air-pump of 12 inches diameter worked by four men. Although the joints were

but roughly and imperfectly made, a vacuum was attained when both ends of the pipe were plugged, equal to a column of twenty-five inches of mercury; and but little less when the piston was in the pipes. This piston raised 84 lbs. weight perpendicularly over a pulley, besides drawing a carriage on the railway, which weighed 160 lbs.

The next trial was made on an ascent of one in thirty, with the same pipe, but increased in length to 102 feet, and exhausted by the same air-pump, which was on this occasion attached to the steam-engine at the works. A cock was also placed close to the pipes, to separate them from the pump, when required for the purpose of better ascertaining the leakage in the pipe itself. A vacuum gauge was attached to each end of the pipe, to ascertain the time that would be required to obtain an equal vacuum throughout its whole length. On this occasion the carriages, which were loaded with iron, weighed *twenty hundred weight*, and were drawn up with great ease. The vacuum at both ends of the pipe was obtained at the same moment of time, and the two gauges rose and fell simultaneously. In order to ascertain the real leakage in the pipe and continuous valve, the ends of the pipe were plugged, when the vacuum gauge rose to $27\frac{3}{4}$ inches of mercury. The cock was then shut, and the mercury was six minutes in descending, showing a leakage in 102 feet length of pipe of only three-fourths of a cubic foot per minute.

The main pipe is put together with deep socket joints, in each of which an annular space is left about the middle of the packing, which is filled with a fluid, and thus any

possible leakage of air into the pipe is prevented. Should the fluid pass through the packing,—a circumstance very unlikely to occur,—it can be easily replenished.

A receiver is attached to each steam-engine, having an internal capacity as large as the section of pipe which the engine has to exhaust. This receiver is exhausted by the air-pump when the train piston is not in the pipe, so that the engines are constantly at work, after one train has passed generating power for the next. The pipe itself is also exhausted in the interval between the exit of one train and the entrance of another. No pipe is laid on a descending plane, except where that descent occurs in the middle of a section, in which case the pipe has no valve or lateral opening, and is laid below the surface. Whenever a train has passed out of a section of pipe, the pump is employed, first, to exhaust the receiver to the greatest possible degree, and then to exhaust the pipe to the degree required for the train.

WE will now compare the advantages and defects of the present and proposed systems.

1stly. The loss of power occasioned on the locomotive system by the engines having to draw their own weight, is entirely saved, and steep hills may be ascended with less additional power than that actually due to the acclivity; for as the rarefaction in the pipe is necessarily increased, the friction of the air through it (at all times very slight) diminishes almost to nothing, and the power, suffering less reduction from this cause, is most effective when most required.

It may be here remarked, that there is no other known power which can be applied to locomotion without carrying considerable weight and friction with it. The ill effects of the weight of locomotive engines having been already pointed out, the same in every respect exists in the application of ropes, which must be drawn along with the train, and become an increased incumbrance on inclined planes. The defects of ropes in other respects are too generally known to need comment.

2ndly. The rails and chairs by the new system need not be more than one-third of the weight required where locomotive engines are employed; and the stone blocks may also be smaller. The carriages of the train are too light to injure the rails or fastenings, as the weight is distributed over a large surface. The annual charge of maintenance of way will, from the same cause, be reduced to one-third of the present cost.

3rdly. The wear and tear of locomotive engines, compared with stationary engines, is as fifteen to one.

4thly. By the new system the full power of the engines is always obtained; and whatever additional quantity of fuel is consumed in ascending, an equal quantity is saved in descending, as the trains run down by their own gravity; therefore the saving of fuel will correspond with the waste which now takes place in the locomotive system,—a waste equal, as we have shown, when the railroad is level, to one-half at a mean speed of twenty miles per hour, and three-fourths at a speed of thirty miles. We should add, that as no railroad is a perfect level, the saving will be considerably greater. The saving of expense in the article of fuel will also be further increased, inasmuch as the cost of coke is three times greater than that of coal.

It may be here remarked that on the new system, with a fixed quantity of traffic per diem, no increase in the fuel consumed, wear and tear, or any other expense, is incurred for an improved speed, further than the small additional power occasioned by atmospheric resistance. An actual saving in the first cost of the railway constructed for a high velocity may be effected, because, by performing the journey in less time, a greater number of trains may be dispatched each day, and their weight diminished. The piston having less to draw may be smaller in diameter, as well as the pipe in which it works. The cost of this pipe (which forms the largest item in the first cost of the railway) will be thus reduced in nearly the same proportion as the speed is increased.

Besides these advantages in point of cost, this system

possesses another of still more importance to the public. No collision between trains can take place, for as the power cannot be applied to more than one piston at a time in the same section of pipe, the trains must ever be two miles apart from each other ; and if from any cause a train should be stopped with the piston in the middle of a section of pipe, the train which follows it will be obliged to stop also at the entrance of the pipe, as there will be no power to propel it until the first train is out. It is also impossible for two trains to run in opposite directions on the same line, as the power is applied to only one end of each section of pipe.

We now come to the comparative cost of the two systems.

1st. The necessity of having the railroad level, causes the greater part of the present enormous outlay for earthwork, viaducts and tunnelling : it also increases the cost of land, not only by lengthening the line to save cutting and embankment, but by the extent of land wasted on each side of the road, wherever an embankment or cutting is required. Thus if an embankment has to be made thirty feet high, sixty feet of land at least must be covered on each side of the railway in order to obtain sufficient slope, making a width of 120 feet, besides the road ; and the same will be required for cuttings, except where they occur in stone or chalk. The comparative expense of this item between the old and new systems, can best be ascertained by comparing the average cost of forming a turnpike road with the average cost of the principal locomotive railways now in operation.*

* Our calculations are founded on the reports of the different companies whose railways are complete or in a forward state.

LOCOMOTIVE SYSTEM.

Taking five of the principal railroads as the base	£.	s.	£.
of our calculation, the average expense of completing them has been per mile . . .			40,000
Original stock of locomotives per mile . . .			2,000

NEW SYSTEM.

The average cost of forming the best turnpike roads throughout England . . . per mile	2,000	0
Allow extra for road bridges . . . ditto	1,500	0
Rails, chairs, and blocks, including laying down, per mile	2,500	0
Main pipe, 10 inches diameter, fitted with valve, &c., complete, including laying and making joints, per mile £6,660, of which three-fifths only must be taken, as no pipe is laid on a declivity, and about 700 feet is allowed between each station for stopping the trains . . . per mile	3,996	0
Steam power, viz. six horse power per mile, in engines varying from six to twenty-five horse power, including exhausting apparatus and engine houses per mile	750	0
Travelling piston and appendages . . . ditto	10	0
	10,756	0
Saving per mile by Clegg's atmospheric railroad	31,244	0
	£42,000	0
		42,000

Annual expense of working per mile when conveying
1,400 ton per day—the average daily quantity conveyed
on the Liverpool and Manchester Railway.

LOCOMOTIVE SYSTEM.

	£.	s.	£.
Five per cent. interest of money for capital sunk	.	.	2,100
Maintenance of way, namely, the derangements caused by the locomotives, per mile, per annum	.	.	*600
Locomotive power, exclusive of coke	.	.	*1,100
Coke, (including waste) 1 lb. per ton per mile	.	.	*341

Carriages, wear and tear, office expenses, resident
engineers, and directors, same on both systems.

NEW SYSTEM.

Five per cent. for interest on capital sunk	522	16	
Maintenance of way	200	0	
Wear and tear of engines, and exhausting apparatus	50	0	
Coal 0·54 lb. per ton per mile	61	13	
Wages to engineers and stokers, and attendants on trains	312	0	
Renewal of travelling piston	50	0	
Valve and main	50	0	
	1,246	9	
Annual saving per mile by Clegg's atmospheric railroad	2,894	11	
	4,141	0	4,141

From recent experiments it has been found that the
wear and tear to the roads, and the locomotives, and the
quantity of coke consumed, is doubled when 35 miles per

hour, the lowest speed proposed by the new system, is attained, and therefore the three items thus marked *, maintenance of way, wear and tear, and cost of coke, should be doubled.

	£	s.
If, then, we add to the expenses of the old system as above	4,141	0
The additional expense of those three items marked thus *	2,041	0
The total cost of the old system at a speed of thirty-five miles per hour is obtained	6,182	0
From which if we deduct the expenses of the new system	1,246	9
The total saving per mile per annum effected by Clegg's atmospheric railroad is seen	4,935	1
Thus if 1,400 tons are conveyed per day, on a railroad 100 miles in length, (equal to the London and Birmingham Railroad,) at a mean speed of thirty-five miles per hour, an annual saving would be effected of	493,550	
When conveying the same quantity at a mean speed of twenty miles per hour, the annual saving would be	289,455	

A more striking example of the inefficiency of locomotive power cannot be given than that exhibited in the following Table, extracted from the last edition of Mr. Wood's Practical Treatise on Railroads.

Gross load in tons which a locomotive engine, capable of evaporating sixty cubic feet of water per hour, will drag, exclusive of the tender, at the under-mentioned rates of speed, on different inclinations of planes.

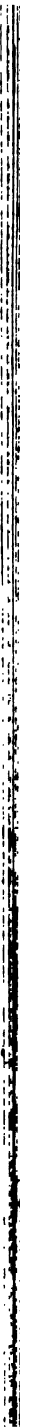
Inclination of plane.	10 miles an hour.	12½ miles an hour.	15 miles an hour.	17½ miles an hour.	20 miles an hour.	22½ miles an hour.	25 miles an hour.	27½ miles an hour.	30 miles an hour.
Level	tons. 346·	tons. 251·10	tons. 187·84	tons. 142·64	tons. 108·75	tons. 82·38	tons. 61·29	tons. 44·04	tons. 29·66
1 in 4480	325·72	236·09	176·35	133·66	101·65	76·75	56·83	40·54	26·95
1 in 2240	307·58	222·67	166·06	125·62	95·30	71·71	52·84	37·40	24·54
1 in 1120	276·47	199·65	148·44	111·85	84·41	63·07	45·99	32·03	20·39
1 in 1000	269·87	194·76	144·70	108·93	82·11	61·24	44·54	30·89	19·51
1 in 900	264·59	190·85	141·70	106·58	80·25	59·77	43·38	29·98	18·80
1 in 800	255·56	184·17	136·59	102·5	77·09	57·25	41·40	28·42	17·60
1 in 700	246·17	177·22	131·27	98·43	73·81	54·65	39·33	26·79	16·35
1 in 600	234·68	168·72	124·75	93·34	69·78	51·46	36·80	24·81	14·82
1 in 500	220·02	157·87	116·45	86·85	64·65	47·38	33·58	22·28	12·86
1 in 400	201·04	143·82	105·69	78·44	58·01	42·11	29·40	19·	10·33
1 in 300	175·39	124·85	91·16	67·09	49·03	34·99	23·76	14·57	6·91
1 in 200	138·48	97·54	70·24	50·74	36·12	24·74	15·64	8·20	1·99
1 in 100	84·07	55·30	37·89	25·46	16·14	8·88	3·09	—	—

We shall conclude by observing that Clegg's patent atmospheric system can be applied to railroads now constructed, or to turnpike roads with their existing gradients. In the one case stationary engines are substituted for locomotives; and in the other, the road may be converted altogether into a railway, or widened, and a portion of it left for the ordinary traffic.



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